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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Magnesium Alloys having a High Resistance to Permanent Creep Deformation at Elevated Temperatures

I, HANS JOACHIM FUCHS, a German Citizen, personally responsible partner of OTTO FUCHS, K. G., of Meinerzhagen, Westfalia, Germany, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to magnesium alloys having a high resistance to permanent creep deformation at elevated temperatures.

Magnesium alloys which have a high resistance to permanent creep deformation at elevated temperatures are known. They contain for instance up to 12% thorium, up to 2% zirconium, and possibly zinc in quantities not exceeding 5%, but they contain no aluminium as this element forms high melting compounds with zirconium which are insoluble in the molten magnesium and therefore segregate.

Other known magnesium alloys with high creep resistance at elevated temperatures contain rare earth metals and possibly one or more of the following metals in the amounts indicated: manganese up to 2%, zinc up to 10%, thorium up to 10%, calcium up to 0·2% and aluminium up to 2%. High creep resistance is also obtained in magnesium alloys incorporating zinc and zirconium insofar as they also contain cerium. However, all these known alloys are expensive and some of them are difficult to handle metallurgically and in the foundry.

It is known that the burning of magnesium and its alloys during melting and casting operations can be prevented by incorporating between 0·25 and 0·5% calcium therein. Moreover, other magnesium alloys are known which contain additions of between 0·08% and 0·5% calcium to achieve a controllably increased toughness, hardness, and strength in the initial alloy.

It has now been found that high resistance to permanent creep deformation at elevated temperatures can be achieved in magnesium alloys containing up to 10% aluminium and up to 0·5% manganese, with a possible zinc content of up to 4%, if these alloys also contain more than 0·5 and up to about 3% calcium.

Accordingly, the present invention provides a magnesium alloy which contains from 2 to 10% aluminium, from 0 to 4% zinc, from 0·001 to 0·5% manganese and over 0·5 and up to 3% calcium, the remainder being commercial magnesium, and in which copper and silicon impurities do not individually exceed 0·5%.

It is preferred, however, that the calcium content should not exceed 2·5% because contents between 2·5 and 3% cause some embrittlement of the alloys. Low contents of copper and silicon up to 0·5% each, such as are present for instance when scrap is used do not impair the action of the calcium in increasing creep resistance at elevated temperatures.

The magnesium alloy according to the invention may further contain beryllium in an amount up to 0·005%.

All magnesium alloys have a content of iron which must be regarded as constituting an impurity and this may already be present in the virgin magnesium or it may have been introduced in one of the alloying constituents or caused by the usual melting process in iron crucibles. However, it has been the general aim to take suitable measures for keeping the iron content below 0·01%, preferably below 0·005% in heretofore proposed magnesium alloys.

The magnesium alloys according to the invention differ from th corresponding alloys without calcium in that they exhibit no typical tendency to form cracks However, it was found that any such tendency (so far as it exists in the alloys containing calcium) can be suppressed with considerable

[*Price 3s. 6d.*]

certainty or at least reduced to a fully satisfactory extent by ensuring that the iron content of the alloys is not less than 0·01% and preferably between 0·015 and 0·03%. The upper limit for the iron content of the alloys may be taken as 0·1% since above this limit it is very difficult to dissolve iron in molten magnesium.

In magnesium alloys as proposed by the invention the manganese content is preferred to be between 0·05 and 0·25%, the calcium content between 0·8 and 1·8% and the zinc content, if any, between 0·2 and 3·5%.

The resistance to permanent creep deformation at elevated temperatures of known magnesium alloys such as the alloy "AZ91" which contains 7·5 to 10% aluminium and 0·3 to 2% zinc, the alloy "AZG" which contains 5·5 to 6·5% aluminium and 2·5 to 3·5% zinc, the alloy "AZM" which contains 5·5 to 6·5% aluminium and 0·5 to 1·5% zinc, and the alloy "AZ31" which contains 2·5 to 3·5% aluminium and 0·5 to 1·5% zinc, all of which incorporate 0·05 to 0·25% manganese, can be substantially improved by the presence of a further 0·8 to 1·8% calcium. These alloys will then find a multitude of applications in cases where an adequately high resistance to permanent creep deformation at temperatures between 200 and 250°C. is needed; for example in structural components for turbine power plant and nuclear reactors, as well as in engine casings.

The following Examples may serve to illustrate the invention.

Example 1

A magnesium alloy, without calcium, containing 9% aluminium, 1% zinc, 0·1% manganese, remainder magnesium, and corresponding alloys containing 0·31%, 0·63%, 1·75% and 2·2% calcium were submitted in their ascast condition to a creep test at 200°C. by the application of a load of 3 kg/sq. mm. Fig. 1 of the accompanying drawings shows the total elongation measured under load in the course of 50 hours.

The total elongations at the end of 40 hour tests with increasing calcium contents are shown in Fig. 2.

Example 2

Magnesium alloys containing 6% aluminium, 3% zinc, 0·1% manganese, and 0, 0·9, 1·3 and 2·25% calcium were creep tested as-cast at 200°C. by the application of a load of 3 kg/sq. mm. Fig. 3 shows the total elongation of these alloys measured under load in the course of 50 hours.

Example 3

Magnesium alloys containing 3% aluminium, 1% zinc, 0·1% manganese, and 0, 0·65, 1·3 and 1·9% calcium were submitted in the as-cast condition to a creep test at 200°C. by the application of a load of 5 kg/sq. mm. Measured under load at the end of 30 hours the alloy containing:—

0% calcium exhibited a total elongation of 0·68%,

0·65% calcium exhibited a total elongation of 0·31%,

1·3% calcium exhibited a total elongation of 0·25%,

1·9% calcium exhibited a total elongation of 0·25%.

Example 4

Magnesium alloys containing 6% aluminium, 1% zinc, 0·1% manganese and 0, 1·4 and 2·4% calcium respectively were submitted as-cast to a creep test at 200°C. by the application of a load of 3 kg/sq. mm. Measured under load at the end of 40 hours the alloy containing:—

0% calcium exhibited a total elongation of 0·32%,

1·4% calcium exhibited a total elongation of 0·17, %

2·4% calcium exhibited a total elongation of 0·09%.

The castability of alloys constituted according to the invention is by no means impaired by the presence of the calcium and as expected their tendency to burn is considerably reduced. The calcium contents have no adverse effect upon corrosion resistance. An important feature is the fact that the tendency of alloys according to the invention with high aluminium or zinc contents to form shrinkage micro-holes is considerably reduced by comparison with corresponding alloys having no calcium. The earlier observation that magnesium alloys with calcium contents of 0·1 to 0·2% have a greater tendency to crack formation was not found to apply in the case of calcium contents over 0·5%, especially if at the same time the iron content was not under 0·01%.

In the case of a magnesium alloy containing, by way of example, 9% aluminium, 1% zinc 0·1% manganese and 1·8% calcium it was also found that the yield point in the range between 20 and 300°C. is higher in alloys according to the invention than in alloys containing no calcium.

The magnesium alloys according to the invention can be used both as casting alloys for sand, chill, and pressure castings, and as plastically-deformable, malleable alloys.

WHAT I CLAIM IS:—

1. A magnesium alloy which contains from 2 to 10% aluminium, from 0 to 4% zinc, from 0·001 to 0·5% manganese and over 0·5 and up to 3% calcium, the remainder being commercial magnesium, and in which copper and silicon impurities do not individually exceed 0·5%.

2. An alloy as claimed in Claim 1, which also contains up to 0·005% beryllium.

3. An alloy as claimed in Claim 1 or 2, which contains between 0·01% and 0·1% iron.

4. An alloy as claimed in Claim 3, which

contains between 0·015 and 0·3% iron.

5. An alloy as claimed in any preceding Claim, in which the manganese content is 0·05 to 0·25%, and the calcium content is 0·8 to 1·8%.

6. An alloy as claimed in Claim 5, in which the zinc content is from 0·2 to 3·5%.

7. An alloy as claimed in Claim 5, in which the aluminium content is 7·5 to 10%, and the zinc content is 0·3 to 2%.

8. An alloy as claimed in Claim 5, in which the aluminium content is 5·5 to 6·5%, and the zinc content is 2·5 to 3·5%.

9. An alloy as claimed in Claim 5, in which the aluminium content is 5·5 to 6·5%, and the zinc content is 0·5 to 1·5%.

10. An alloy as claimed in Claim 5, in which the aluminium content is 2·5 to 3·5% and the zinc content is 0·5 to 1·5%.

11. A magnesium alloy according to any one of the preceding claims having a high resistance to permanent creep deformation at elevated temperatures, substantially as hereinbefore described in any of the foregoing Examples.

W. H. A. THIEMANN,
Prestige House,
14 to 18, Holborn,
London, E.C.1.
Agent for the Applicant.

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200°C , 30 MPa

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2 SHEETS

FIG.1

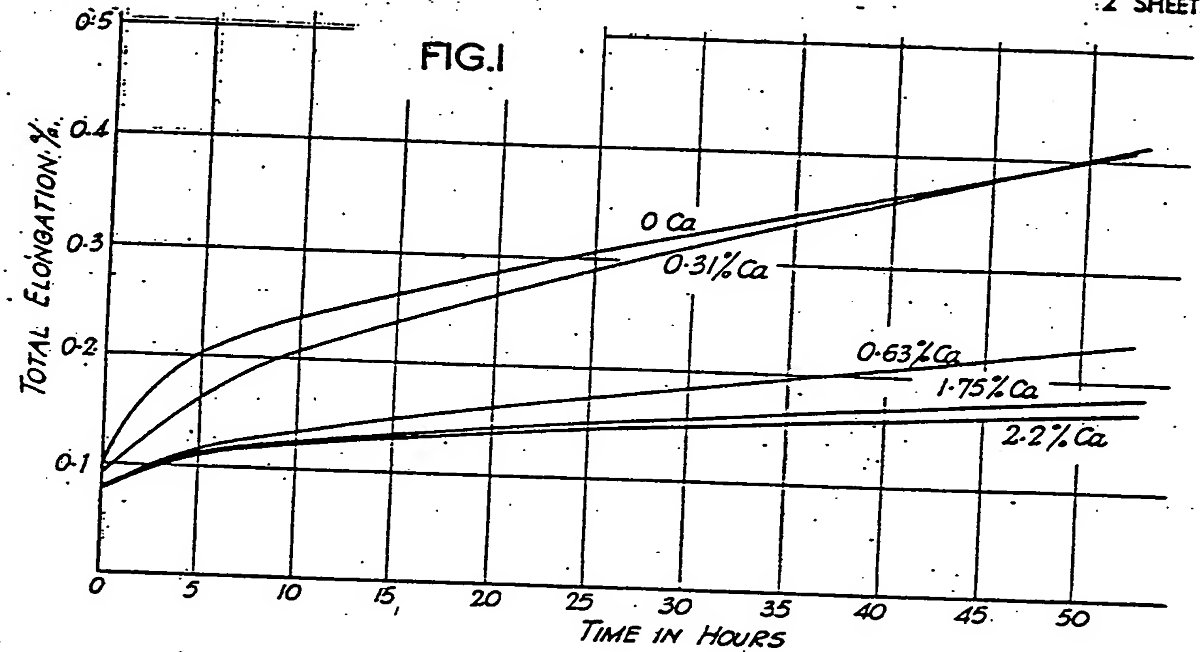
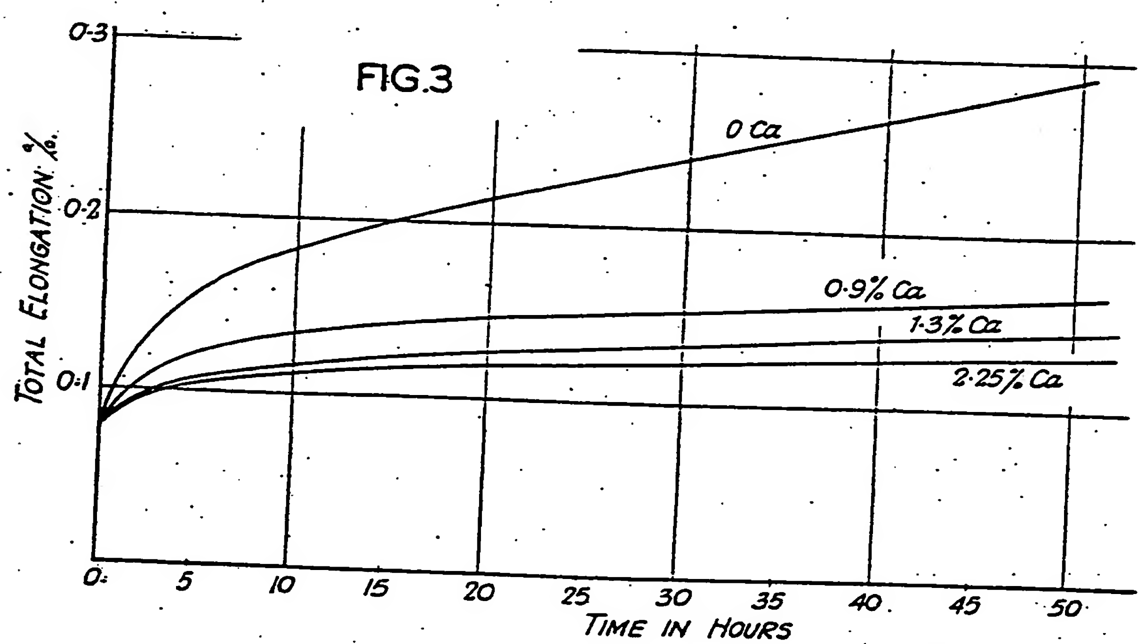


FIG.3



200°C , 30 MPa

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2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEET 2

FIG.2